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Soviet High-Technology Restructuring Drive: The MNTK Network

Simon Kassel

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PREFACE

This Note assesses the nature and effectiveness of a new type of Soviet scientific-industrial organization, a network of interbranch science and technology complexes (MNTKs) designed to stimulate the development of advanced technologies.

The study was sponsored by the Defense Advanced Research Projects Agency, Office of the Secretary of Defense (OSD), and was carried out in the Applied Science and Technology Program of the National Defense Research Institute, RAND's OSD-supported Federally Funded Research and Development Center.

SUMMARY

The recent establishment of a network of interbranch science and technology complexes, known as MNTKs in Soviet parlance, represents the latest and strongest attempt to overcome the chronic Soviet lag in advanced technologies. The new organizations have been created within the framework of the current drive to restructure the Soviet economy, as a means of integrating science and industry. The MNTKs are impressive in the speed of their introduction, their size, and the unprecedented nature of their charter.

One-and-a-half years after the enabling legislation, there are 23 MNTKs, some of which incorporate dozens of scientific research institutes together with large industrial production enterprises and several science production associations. For the first time, an effort has been made to engage the institutes of the Academy of Sciences on a massive scale in the industrial innovation process. The MNTKs are conceived as bridges spanning the gap between leading Academy research and industry; at the same time, they integrate different research topics and different industrial branches in an attempt to solve the problem of interdisciplinary operations in science and technology.

The MNTKs were granted a series of new economic powers to ensure their effectiveness. They have the right to negotiate directly with the ministries and agencies of the Soviet government, to enter into separate contracts with Council for Economic Mutual Assistance (CEMA) countries, to sell their production directly abroad, to earn hard currency, to control the use of their profits, and to demand additional funding above the plan if required by changing circumstances. They also have priority in the provision of resources.

But these rights fail to go far enough to include the most decisive means of overcoming the technological stagnation of Soviet industry--direct incentives to innovate in industrial production. The main thrust of the MNTK reform is directed more toward the problem of organizational barriers than toward economic obstacles.

The technological profiles of the MNTKs show a similar conservatism; more of them are oriented toward materials and process improvement in the metallurgical, machine-building, chemical, and oil extraction industries than toward advanced technologies dominant in the West, such as electronics, computers, plastics, and composites. Some MNTKs in the latter category, dealing with electron-optic sensors, fiber optics, radiation, and automation, are known by name only. Since these subjects are particularly important to the military, it is possible to infer the existence of a series of less visible MNTKs with a military orientation.

The promise of the MNTK network as the principal instrument for solving the problem of advanced technologies is threatened by the considerable cleavage between the government's plans and decrees, and their realization in practice. In contrast to the speed of their formal establishment, further steps toward practical implementation of the MNTKs have been quite slow. Bureaucratic resistance has been eroding the effectiveness of the new organizations, particularly the power to enforce their new rights and privileges. As a result, Soviet observers question the potential of the MNTKs, and some critics already call them paper tigers. In balance is Soviet capability for technological and military competition with the West.

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I. INTRODUCTION

An interesting development in the course of the economic reform taking place in the USSR is the recent establishment of a new type of organization, the interbranch science and technology complex, known by its Russian acronym as the MNTK. The new organization represents the latest, the most ambitious, and the most determined in a long series of past Soviet attempts to deal with the intractable problem of introducing the results of advanced scientific research into industrial production. A successful solution of this problem would place Soviet advanced technology on a par with Western achievements.

This Note assesses the MNTK project and the 23 MNTKs that have appeared so far in the Soviet press. After outlining the situation leading to the MNTK reform, the Note analyzes the structure, special features, and topical distribution of the MNTKs, and views their intended capabilities in the light of early Soviet comments on their operation. The Note concludes with an assessment of the impact the MNTKs are likely to have on the development of Soviet advanced technologies. An appendix provides the currently available information on each reported MNTK.

II. THE PROBLEMS OF SOVIET ADVANCED TECHNOLOGY DEVELOPMENT

Among the various issues involved in the declining industrial performance in the Soviet Union, problems with Soviet advanced technologies have been assuming an ever greater importance. One reason for this is the steadily increasing role of advanced technologies in the military industries. A more immediate and compelling issue is the prospect of space technology competition with the United States, triggered by the Strategic Defense Initiative, to be pursued almost exclusively in the area of advanced technologies. The most important issue, however, is the key role that advanced technology is expected to play in reversing the downward trend in productivity growth rates threatening further development of Soviet military and civilian technologies alike.

The unsatisfactory Soviet position in this area of technology must, therefore, be a matter of great concern to the Soviet leadership, and it could well have served as a major stimulus to the current Soviet economic reform.

The many complex factors underlying the shortfalls in Soviet advanced technologies can be roughly classified into three categories: economic disincentives to innovation, organizational problems, and operational deficiencies.

Economic disincentives stem from many features characterizing Soviet industry. The practical application of scientific research results depends first of all on the readiness of industry to translate these results into production, or, to use a technical term, to innovate. But the Soviet industrial system is strongly biased against innovation. The absence of a free market and supply-and-demand conditioned pricing eliminates competition as a factor in stimulating innovation. Moscow's insistence on centralized control thwarts in individual plant managers the incentive to innovate. Rigid quantitative production quotas further stultify innovation, which requires temporary production halts for retooling and retraining. And innovation deficiency, in addition to its obvious results, such as continuing production of obsolete equipment,

has a subtle, but profound, effect on scientific research itself by denying it information feedback from industrial production, an essential factor ensuring the ultimate practicality of scientific invention.

Although economic disincentives and their effect on Soviet industrial performance have been widely studied, Soviet organizational problems of industrial innovation are less known in the West. They mainly revolve around the pervasive presence of jurisdictional or bureaucratic barriers in the path of the technological innovation process.

The Soviet system of translating research results into industrial products is based upon a paradox: the principle of centralization that governs many aspects of Soviet economy, often with deleterious results, does not apply to one area where it is most needed--the R&D cycle leading to advanced technologies. The responsibility for developing what the Soviets call new-in-principle technologies rests upon the Academy of Sciences--the planner, coordinator, and performer of R&D involved in these technologies. But the Academy is a powerful, autonomous organization that has no hierarchical linkages and weak economic linkages to the system of industrial ministries ultimately responsible for embedding the new technologies in their production. The Academy and industry are thus separated by a jurisdictional barrier that severely inhibits both the forward transfer of completed research projects to the production stage and the reverse transfer of information and industrial support to enhance research.

The negative influence of this barrier is further aggravated by the diverging economic expectations between the Academy, interested in maximizing the impact of its research, and industry, interested in minimizing the effects of innovation which, in the short run, tend to decrease quantitative output indices.

Another organizational problem, also partly due to jurisdictional barriers, has received the least attention; this is the low inter-institutional mobility of Soviet scientific and technical personnel encouraged by institutional specialization, housing shortages, and personnel policies. Low mobility has an adverse effect on the development of advanced technologies which entails an ever increasing need for interdisciplinary research efforts. To assemble experienced

specialists, they must be detached from other organizations and often relocated. G. I. Marchuk, the current president of the Academy of Sciences, has emphasized this problem, noting that "World science is now based on flexible personnel teams...that can be quickly formed with specialists drawn from outside sources. Soviet institutions have no such mobility, but conditions for fast relocation of cadres should be created at least in the Academy's institutes."[1]

Jurisdictional barriers also impede coordination of interdisciplinary projects and the flow of information among participating organizations. Technical information flows, in turn, greatly benefit from adequate turnover of personnel, which promotes the dissemination of new ideas.

Operational deficiencies in the development of advanced technologies result from inadequate distribution of resources along the research-to-production cycle. The most damaging resource problem is the absence of a proper infrastructure of experimental pilot plants in the Academy of Sciences. These plants are needed by the Academy to refine R&D projects to the necessary degree of completion before industry can start the production phase. On the other hand, Soviet industry lacks enough manpower with adequate scientific expertise to receive and process Academy's R&D projects even when they have been completed.[1]

Although Soviet industry has its own network of R&D institutes that is an order of magnitude larger than the network of the Academy of Sciences, the scientific talent of Soviet industrial R&D is not comparable to that of the Academy. The concentration of top scientists in the Academy of Sciences is illustrated by the fact that its Institute of Radio Engineering and Electronics and the Lebedev Physics Institute alone employ almost the same number of doctors and candidates of science as the total in the entire electronics and communications industries.[3] The most important factor, however, is that the industrial institutes do

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[1]According to V. A. Sidorov, deputy director of the Novosibirsk Institute of Nuclear Physics, in many cases industry does not have specialists that would be capable of integrating new technology into the industrial process.[2] Marchuk noted that Soviet industrial research institutes were found unprepared to absorb the results of the Academy's research, even though they receive 90 percent of the science budget, with only 10 percent going to the Academy.[1]

not pioneer advanced technologies--almost always the preserve of the Academy of Sciences.

The scientific eminence of the Academy of Sciences has been threatened somewhat by the extraordinary aging that has overtaken the leadership of the Academy during the last decade. The total number of 274 full academicians [4] has the following age distribution:[5]

Academy members younger than 50 years	
1976	5.8%
1986	0.8%

Academy members older than 75 years	
1976	15.3%
1986	36.6%

The astonishing fact that the Academy has some 100 leading members over 75 years old can be ascribed to their lifetime tenure. But the fact that only one academician[2] is younger than 50 reflects the poor turnover and election policies of the Academy.

Marchuk has recently reported that age limits on Academy leadership have been introduced. All scientific workers, except academicians and corresponding members of the Academy of Sciences, must resign their administrative posts upon reaching the age of 65. This includes directors, deputy directors, and chiefs of laboratories, departments, and sectors. Members of the Academy, in view of their high qualifications and work experience, will have to resign from leadership positions between the ages of 65 and 70 and will then be limited to research and training. It is also planned to rejuvenate the membership of the Academy's institutes without increasing their numerical strength (housing is a problem).[7]

Many jurisdictional barriers and operational deficiencies seem to stem from the phenomenon of the Academy of Sciences dominating Soviet research. The separate existence of the Academy disrupts the process of industrial introduction of its own research results. The strong

[2]Identified as S. P. Novikov.[6]

tendency of the Academy to absorb and concentrate scientific talent of the nation within its ranks deprives industry of the necessary level of resident scientific expertise, and at the same time deprives the Academy of technological support that is potentially available in industry. The Soviet Academy is a unique organization in the world of science; as an independent and nearly exclusive performer of the most advanced research in the nation, it has no counterpart in other industrially developed countries.

The power to draw the best scientists stems from the well-earned prestige and privileges of the Academy of Sciences, and from its position as the principal site of basic research in the USSR. But the Academy fails to challenge its implicit premise that basic research must have first claim on the best scientists, or that top scientists are wasted on industrial research. Neither does the Academy make a serious effort to increase the low mobility of its personnel and divert them to industry.

In addition to the effect of the Academy, the distribution of Soviet scientists has been skewed by the old cultural bias in favor of theoretical science and the scarcity of experimental equipment, creating an excess of working theoreticians. The resulting scarcity of experimentalists, the pull of the Academy, and the overproduction of engineers[3] by Soviet universities, have starved Soviet industry of scientific talent.

Nevertheless, the Academy of Sciences, as the principal seat of scientific excellence, is critically important to the Soviet Union both in ensuring the progress of basic research and in promoting the development and application of advanced technologies. It is regarded as a most valuable national resource whose benefits far outweigh any costs incurred by its problems.

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[3]G. A. Yagodin, USSR Minister of Higher and Secondary Specialized Education, notes that while the USSR graduates almost as many highly qualified specialists as the United States, there are 3.8 times more engineers in the USSR than in the United States and the USSR graduates 3.1 times more engineers per year than does the United States. However, only 14 non-engineering specialists are graduated for every 10 engineers in the USSR, as compared with 32 in France, 37 in West Germany, and 114 in the United States. Yagodin questions the Soviet need of so many engineers at their present qualification level.[8]

The two roles of the Academy--pursuit of independent basic research and involvement in industrial innovation--have been a source of considerable conflict within its ranks. Some academicians believe that the Academy should be dedicated entirely to basic research, which means to science itself. This position implies more independence for the Academy, albeit at the cost of greatly diminished political power and influence in national affairs. Others favor more involvement with industry and the attendant rise in income and influence, even at the cost of some loss of independence. The history of the Academy reflects this conflict and reveals wide swings in Academy orientation between the two positions. During World War II, the Academy was heavily engaged in defense work and, during the late 1940s, in the development of nuclear weapons. The 1950s marked a swing toward basic research culminating in the transfer of many of the Academy's institutes to industry in 1961. Since that time, spurred by the government's concern with industrial conservatism and the promise of contractual funding, the Academy has steadily regained lost ground in the shift toward applied research and development.

The current economic and industrial reforms have eliminated any doubt about the role of the Academy of Sciences, now firmly committed to massive interaction with industry. Soviet leadership has assigned a high priority to restructuring the R&D process, leading to the development of advanced technologies within the framework of the drive to "accelerate social and economic development" formulated by the 27th Party Congress.[9,10] Restructuring will attempt to redress the economic, organizational, and operational problems discussed above.

The thrust of the restructuring effort is directed first toward the barrier problem by erecting a bridge between the Academy of Sciences and industry--the set of interbranch science and technology complexes, or MNTKs.[4] The MNTK system was established late in 1985 by a joint decree issued by the CPSU Central Committee and the USSR Council of Ministers which directly oversees the MNTKs.[9-11] While the composition of each

[4]The Russian acronym for Mezhotraslevyy Nauchno-Tekhnicheskiy Kompleks.

MNTK is designed to minimize the organizational problem of advanced technology development and the attendant jurisdictional barriers, a series of special powers and privileges granted to the MNTKs is expected to deal with the other two problem categories--economic and operational.

III. THE NATURE OF THE MNTK SYSTEM

Elaborate bridges between R&D and industrial production are fairly common in the more traditional Soviet technology areas. These are the well-known science-production associations (NPO) linking research institutes of the industrial ministries, design bureaus, and industrial enterprises. They were created to overcome another, somewhat less formidable, bureaucratic barrier within the industrial ministry system between industrial research and industrial production.

In some estimates, the industrial barrier accounts for the current average period of 10 to 12 years from the start of development to the organization of serial production of new technology. The separate existence of industrial R&D and production means new technology is developed in the R&D institutes and design bureaus without consideration of the actual capabilities of the production plants. Thus it often happens that when production of new technology is assigned to a manufacturing plant, it is easier for it to downgrade the new project to the plant's technological level than to bring the plant up to the level required by the new technology.[12]

The performance of NPOs has been indifferent, mainly because they have not been granted enough legal power to enforce efficient interaction among their constitutent agencies. As a result, the majority of NPOs merely combined their science and production components administratively, without a thorough integration of their operations. The component institutions thus continue to exist separately within the NPOs, pursuing their own standard agendas and reflecting the same conflict of interest between research and production that affects the industry as a whole.[13] Many such associations are NPOs in name only. When an NPO includes mass-production plants, its scientific research institutes gradually lose their character, turning into an "appendage" of production. This happens because state plans treat such NPOs as ordinary industrial enterprises and exclude such output indices as the scientific and technical level of production.[12,13]

Another obstacle to successful integration is inherent in the legal status of the NPOs. Their two main components, R&D and production, remain independent legal entities with their own systems of rewards and incentives, and are subject to different funding jurisdictions. The R&D institutions fall into the state budget category of "Science and science service" controlled by the State Committee for Science and Technology, whereas production is the province of Gosplan.[12]

Of course, there are exceptions to this trend. One is the nation's first NPO, the Kriogenmash, established in 1972 to develop and manufacture cryogenic equipment. It combined the industrial All-Union Kislorodmash Research Institute with the Balashikhinskiy Plant under a common management and common party and labor union organization. According to its organizer, V. P. Belyakov, who bears the title of general designer of cryogenic technology, the Kriogenmash NPO has been successful because of the unified management, party, and labor structure and because it has achieved close cooperation between its scientists and production specialists. An important factor has also been a continuing effort of the institute to ensure the plant's readiness before the latter is assigned new technology for mass production.[1][12]

A recent development, stemming from the success of the Kriogenmash NPO, is the creation of a kind of super NPO, the All-Union NPO (VNPO). The Ministry of Chemical Machine-building Industry (Minkhimmash) organized Kriogentekhnika (Cryogenic Technology) as the first VNPO, which absorbed all the NPOs and plants previously operating in the cryogenic field. The Kriogenmash NPO became the head organization of the VNPO. In addition, the latter absorbed the Odessa Kislorodmash

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[1]The success of Kriogenmash NPO must also be credited to the groundwork in cryogenic technology and in integrating science with industrial production laid by P. L. Kapitsa, an outstanding Soviet scientist. In the 1930s and 1940s, the Institute of Physics Problems of the Academy of Sciences under Kapitsa became the leader of cryogenic technology. Kapitsa then established the Glavkislorod, an organization for the production of liquid oxygen that employed joint Academy and industrial facilities, an early prototype of the NPO.[14] This venture was made possible by Kapitsa's drive and his remarkable engineering as well as scientific talent, personal attributes that appear to be indispensable for the task of uniting Soviet science with industry.

(Oxygen Machines) NPO, the Omsk Mikrokriogenmash NPO including the Omsk plant for oxygen machine construction, the Moscow Geliymash (Helium Machines) NPO, and the Sverdlovsk plant for oxygen machine construction.[12]

Belyakov claims that the VNPO combines the advantages of all its components and eliminates the shortcomings they had when standing alone. The VNPO can address a broader range of tasks and pursue a single technology policy in all plants manufacturing cryogenic equipment. Although it assumes a part of the ministry management function, the VNPO is primarily dedicated to the technological policy of ensuring world-level mass production.

VNPOs are now being organized in several other industrial branches. But Belyakov questions whether the general designer and general director of the VNPO will have enough legal power to be effective. Although the Council of Ministers, USSR, has conferred broad enough rights on the general designers, they tend to be ignored by the industrial ministers. Belyakov regards the VNPOs as a favorable alternative to the MNTKs. However, the NPO system is for the most part internal to the industrial ministries, does not involve the Academy of Sciences institutes, and does not engage in the development of advanced technologies.

The new MNTK system represents the first large-scale attempt to link the institutes of the Academy of Sciences and its advanced technology capability directly with industrial production. In their function of spanning science and industry, the MNTKs are similar to the NPOs. However, the "interbranch" designation in their name signifies that another key function is to span different industrial areas and different scientific research areas, thus affording a solution to the problem of an interdisciplinary approach to the development of advanced technologies. To realize this bridging function, each MNTK, specializing in a stipulated advanced technology, embraces a number of institutions from the Academy of Sciences and from several ministries and other agencies.

The MNTKs also differ from the NPOs in their size and scope. A number of MNTKs include in their organization several NPOs and some of the largest industrial production enterprises of the USSR. The MNTK system thus appears as the most ambitious venture launched by the

Soviets so far to solve the problem of industrial innovation, and the most telling testimony to the importance of advanced technology in the perception of Soviet leadership.

Marchuk, the president of the Academy of Sciences, has been the most voluble exponent of the merits of MNTKs. In his words, "The MNTKs are a new organizational and economic form of integrating science and production and of concentrating scientific, technical, and material resources on solving major technological problems and creating and introducing fundamentally new types of equipment and processes."[15]

The MNTKs are expected to coordinate and perform all R&D work in their area of technology from basic research to the construction of prototypes and beyond, refining the R&D projects with industrial participation to the point where they can be introduced into mass production. The MNTKs are also responsible for seeing that the technology they develop is widely disseminated throughout the industry.

Along with the primary drive to resolve the institutional barrier and interdisciplinary R&D problems, the MNTK system has been endowed with the power to deal with some of the economic obstacles to technological development.

The most promising aspects of this power include the right to make additional requests for resources above the plan and to demand a quick response from the relevant supply agencies and ministries, priority in the establishment of pilot production bases, priority in ordering materials and resources, and the right to demand full delivery of the ordered amounts.[15] The MNTKs are also empowered to deal directly with any ministry and agency, to sell their production directly abroad, without middlemen, to earn hard currency, and to control the use of their profits.[16]

To implement the right to additional unplanned funding, the State Committee for Science and Technology established a reserve fund for MNTK financing and manpower.[15]

The MNTKs also have the right to formulate proposals for the state Five-Year Plans in their areas of activity, and the right to establish direct scientific, technical, and production relations with CMEA member countries.

The Council of Ministries controls the organization of the MNTKs. It appoints the general director of each MNTK and approves the list of organizations which are part of the MNTK. Each MNTK is led by a so-called "head institution," usually, but not necessarily, represented by a major research institute of the Academy of Sciences. The head institution is administratively superior to all the other participating organizations, regardless of their affiliation. As a rule, the director of the head institution of the MNTK becomes its general director. Each MNTK establishes a council whose decisions are binding on all organizations participating in the MNTK.

The MNTK system, as outlined above, would force the Academy of Sciences to participate in the industrial process to a considerable extent. In this situation, the Academy leadership had to exercise great care in balancing the requirements of goverment and industry against the expectations of its own constituency, which viewed the pursuit of science as its primary mission. Having set off on the path away from basic research and its privileges, the important consideration was to preserve the integrity and augment the power of the Academy. In the design of the MNTKs, this meant maximizing industrial resources under the Academy's jurisdiction. As stated by A. P. Aleksandrov, the outgoing president of the Academy, "The organization of the MNTK system was a difficult task. We had initially expected that a large number of industrial production enterprises [would] be transferred to the Academy of Sciences.... It became clear, however, that such a transfer [would] create considerable friction between the Academy and industry."[17] Thus, the present form of the MNTK system is a compromise between the Academy's and industry's desires.

To reassure the ranks of the Academy who favor its former position and independence and who are less than willing to go along with its current industrial involvement, Marchuk, the new president, went out of his way to stress the importance of basic research to the Academy. At the same time, he said that the restructuring drive sharply increases the responsibility of industrial science (as distinct from Academy science) for the results of innovation and for new technologies.[18]

But the Politburo's Ye. K. Ligachev had a different outlook: "The Central Committee has recently considered the problems [of unjustified delays in the organization of MNTKs[2]]. The directors of MNTKs, and the leaders of ministries, agencies, and the Academy of Sciences are warned that they are personally responsible for effective utilization of this new-in-principle form of integrating science and production."[3]

The restructuring travails that affect the Academy of Sciences as a whole do not seem to be a problem to B. Ye. Paton, president of the Ukrainian Academy of Sciences, who originated the MNTKs. In the Ukrainian SSR, Paton has been the most successful organizer of past Soviet efforts to integrate science and industry and has created an effective network of associations and programs linking the Ukrainian Academy to local industrial enterprises. One of his early integration efforts was the establishment of scientific-technical complexes consisting of the Ukrainian Academy institutes, design bureaus, and pilot and production plants. In 1977, these complexes were said to employ 22,000 workers. Paton has a profound understanding of the problems affecting Soviet industrial innovation and, particularly, of the role played by the fragmented R&D process.[19] In the current restructuring effort, Paton's Institute of Electric Welding has become the first MNTK.

Paton's success may be partly due to his broad use of the party apparatus in the effort to integrate science and industry. As he put it: "When many industrial enterprises and construction organizations are under the jurisdiction of union ministries, only party influence makes it possible to overcome departmental barriers. The work of the Ukrainian Academy's Western Science Center led by the Lvov party district committee has demonstrated that this influence is highly effective."[20]

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[2]Aleksandrov admitted that problems with the organization of MNTKs are partly his own fault. The main phase of organizing the MNTKs coincided with the Chernobyl disaster, which diverted Aleksandrov, a specialist in atomic energy, from devoting enough time to the MNTKs.[17]

In his book on the Soviet Academy of Sciences,[21] Stephen Fortescue appreciated Paton's emphasis on cooperation with the party, noting that the Presidium of the Ukrainian Academy has signed contracts with all the obkomy (party district committees) of the republic and the Kiyev gorkom (city party committee), and that these contracts cover scientific research work within the boundaries of the regions. According to Fortescue, Paton gave credit for the idea and implementation of the interbranch associations to the obkom, which also drew up the plans and confirmed the management personnel of the associations.

Paton's effective use of the party on the local, or even the republic, level to further his policies could perhaps be emulated elsewhere on the same levels to promote the MNTKs. But such a course is not a matter of policy to be promulgated and followed throughout a system; instead, it is always the result of the personal drive and initiative of outstanding individuals.

IV. THE DISTRIBUTION AND TECHNOLOGIES OF MNTKS

According to the State Plan for Economic and Social Development of the USSR, the MNTK system is designated as the primary developer of advanced technologies. In their speeches to the Supreme Soviet of the USSR, Marchuk and N. V. Talyzin, chairman of Gosplan, provided a list of new-in-principle technologies envisaged in the plan for 1987. The list breaks down into four main areas: complex automation of production, advanced process technologies, biotechnology and medicine, and agriculture technology.[9,22]

Complex automation of production depends on computer and automation technology in which three areas are singled out: large computer systems, personal computers, and microprocessors.

Among advanced process technologies, the plan specifies materials processing based on plasma, radiation, laser, and pulse technologies, welding, powder metallurgy, membrane technologies in chemistry, processes using ultrasound and high pressures, effective processes of complex raw material treatment, and increasing the yield of gas and oil deposits.[9,22]

The specialized areas of the MNTKs reported in the press correspond closely to the technology areas specified in the Plan, down to such idiosyncratic topics as membrane technology for the chemical industry and pulse machines. Table 1 lists the reported MNTKs by technology branch, name, and jurisdiction. The distribution by technology branch is the author's.

One should not assume that all the MNTKs listed in Table 1 are in full operation at this time. All appear to have been approved by the Council of Ministers, but the manner in which material on each MNTK has been reported suggests a wide variation in their organizational and operational status. In general, it is reasonable to assume that the amount of detailed information on a given MNTK is roughly proportional to its degree of completion. For that reason, the four MNTKs in Table 1 with the notation "no data" (no information other than their names) can be considered to exist only in the planning stage.[1]

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[1]An alternative interpretation is that lack of information on some MNTK is due to classification because of sensitivity. This possibility is discussed in the Conclusions.

Table 1

REPORTED MNTKS[A]

MNTK	Principal Jurisdiction	Reference
Computers and Automation		
Personal'nyye EVM (personal computers)	Academy of Sciences, USSR	11,15,23
Robot (automated control systems)	Industry	11,24
Avtomatika (computer-aided automation)	No data	11
Electron-Optics and Scientific Instruments		
Tekhnologicheskiye lazery (industrial lasers)	Academy of Sciences, USSR and industry	11,15
Nauchnyye Pribory (scientific instruments)	Academy of Sciences, USSR	25
Svetovod (light conduit)	Academy of Sciences, USSR	11
Mikrofotoelektronika (miniaturized electron-optics sensors)	No data	11
Radiatsiya (radiation)	No data	11
Metallurgy		
Institut Elektrosvarki im. Ye. O. Paton (Paton Institute of Electric Welding)	Academy of Sciences, UkrSSR	11,15,26,27
Metallurgmash (metallurgy machinery)	Industry	11,15
Poroshkovaya metallurgiya (powder metallurgy)	Academy of Sciences, UkrSSR	11,27

Machine-Building		
Rotor (automated conveyor lines)	Industry	11,28,29
Mekhanbor (advanced crushing and pulverizing)	Industry	11,15
Nadezhnost' mashin (machine reliability)	Academy of Sciences, USSR	15,30
Impul'snyye mashiny (pulse machines)	No data	11
Chemical Industry		
Katalizator (catalyst)	Academy of Sciences, USSR	11,31
Antikor (anticorrosion)	State Committee for Science and Technology (GKNT)	11,15,32
Termosintez (thermosynthesis)	Academy of Sciences, USSR	11,23
Membrany (membrane technology)	Industry	11,15
Petroleum Industry		
Nefteotdacha (oil extraction)	Industry	11,15,32
Biotechnology and Medicine		
Biogen	Academy of Sciences, USSR	11,15
Latbiotekh (Latvian biotechnology)	Academy of Sciences, LatSSR	33
Mikrokhirurgiya glaza (eye microsurgery)	RSFSR Ministry of Health	11,16

[a]The available details on each MNTK are given in the Appendix.

It is useful to consider the jurisdictional and technological breakdown of Table 1 in the light of the avowed Soviet drive to install the MNTK system as the key tool to integrate the Academy's science with industry and so to assure the successful development of advanced technologies. For this purpose, the numbers of MNTKs in this breakdown have been summarized in Table 2.

Table 2

MNTK DISTRIBUTION BY JURISDICTION AND TECHNOLOGY

	Principal Jurisdiction					
Industrial Branch	Academy of Sciences	GKNT	Industry	Health Minis.	No data	Total
Computers and automation	1		1		1	3
Electro-optics and scientific instruments	3				2	5
Metallurgy	2		1			3
Machine building	1		2		1	4
Chemical industry	2	1	1			4
Petroleum industry			1			1
Biotechnology and medicine	2			1		3
Total	11	1	6	1	4	23

Several facts emerge from the breakdown. First, the Academy of Sciences is not in charge of every MNTK. At least six MNTKs are directly under industrial jurisdiction and some may not even include Academy institutes. Thus, the leading-edge research, as practiced by the Academy of Sciences, is not represented in over a third of the reported MNTKs. Second, the technological distribution seems directed more toward improving the existing processes and machines than toward developing advanced materials and devices. For example, one-half of the MNTKs are concentrated in metallurgy, machine-building, and the chemical and petroleum industries, where the primary emphasis is on achieving higher reliability and efficiency of existing systems. No MNTKs have been established, so far, in electronics, to develop composite materials, or to promote the replacement of metal structures, such as

pipelines, with plastics. Third, the computer and electron-optics technologies appear underrepresented, in view of their importance to modern industry and defense, and their severe scarcity in the USSR. Computer technology is represented only by a single MNTK, and that is dedicated more to the production of an existing scarce commodity than to the development of new technologies.

The single MNTK in the computer field represents the only shortfall from the State Plan: For computer and automation technology, the Plan specifies the three areas of large computer systems, personal computers, and microprocessors. Two of these--large computer systems and microprocessors--are missing from the MNTK network.

On the other hand, all three areas are represented in the recent reorganization of the Academy of Sciences in the computer field and the resulting system of Academy-industry linkages, discussed in a previous report by this writer.[34] The Academy-industry computer organization closely parallels the structure of the MNTKs and, in the case of the "Personal Computers" MNTK, actually participates in the MNTK network. This complex relationship of the newly emerging bureaucracies is already showing signs of potential conflict.

Ye. P. Velikhov, vice-president of the Academy of Sciences, in his 1986 report to the Presidium of the Academy, provided a strong, if indirect, indication of his opposition to the MNTK concept in favor of what he calls "interagency centers to accelerate the introduction of Academy's projects into production," to be controlled exclusively by the Academy of Sciences. According to Velikhov, the Physico-technical and Mathematical Sciences Section of the Presidium of the Academy of Sciences has already established several such centers, which are now operating with "varying degrees of success."[35]

In a detailed description of the existing and proposed centers, Velikhov carefully avoided any mention of the MNTK organization, although two centers (personal computers and industrial lasers) are in operation as MNTKs. The Scientific Research Center for Industrial Lasers (the first on Velikhov's list) is the head organization of the "Industrial Lasers" MNTK. While the Academy shares jurisdiction over this MNTK with the Ministry of Electro-technical Industry, Velikhov fails to acknowledge that fact, merely noting that the Academy should

set up a close linkage to this Ministry which should organize mass production of the laser systems. Furthermore, Velikhov said that according to an agreement with the Ministry of Electro-technical Industry, the Center (not the MNTK) will be assigned a manufacturing plant for series production of industrial lasers.

Velikhov also noted the existence of three other Centers at the Academy of Sciences: Center for automatic development of VLSI (very large scale integration), Center for the development of systems for automating design work, and Center for supercomputers. These centers probably fill the elements of the State Plan agenda that were missed by the MNTKs.

The conflict apparent in Velikhov's report on the interagency centers may thus be responsible for the absence of some advanced technologies from the MNTK network. Velikhov's attitude may be traced to the still unresolved question of what are the limits of the Academy's authority over the R&D stages beyond basic and applied research. This question is further compounded by the uncertain status of the MNTKs. The problems arising out of this situtation are explored below, in the section dealing with the actual operation of the MNTK network.

The computer and electron-optics technologies also show the highest proportion of MNTKs marked "no data." If our assumption about the meaning of this designation is correct, four out of the eight MNTKs in these categories exist only on paper. This further strengthens the impression that, in terms of technological innovation, the drive behind the MNTK system is turning out to be much more conservative than Soviet planners would have us believe. On the other hand, these technologies have a particularly high military significance. The absence of published information may thus mean that the four MNTKs are operational, but have a military orientation and are classified.

The above technological limitations do not extend to other dimensions of the MNTK system. The extraordinarily ambitious scope of the system becomes apparent whether one considers the sheer size of the MNTKs, their expected production plans, or the extent of their industrial involvement. The feeling of size of the MNTKs is conveyed by the following examples:

- The "Advanced Crushing and Pulverizing" MNTK will include 10 industrial branch scientific research institutes, 10 Academy and university institutes, and the giant industrial combines Uralmash and Novokramatorskiy Mashinostroitel'nyy Zavod, in addition to other production associations.[11]
- The "Machine Reliability" MNTK will embrace the Institute of Superplasticity of Metals and the Control Design Bureau of Unique Instrument Building, the Spektr, Burevestnik, and Tochmashpribor NPOs, the Central Steam Boiler and Turbine Institute, and the Vibropribor and Tenzopribor plants.[30]
- The "Biogen" MNTK includes the Latvian Bislar NPO, the Special Design Bureau of Biological Instrument Making in Pushchino, six institutes of chemistry, molecular biology, biochemistry, genetics, and plant physiology, and the Main Botanical Garden in Moscow.[15]
- The "Eye Microsurgery" MNTK will include experimental plants and 12 branches throughout USSR.[16]

The projected production share of the MNTKs is similarly ambitious. The "Scientific Instruments" MNTK is slated to build one-third of the total national requirement for scientific precision instruments by 1990. The MNTK's share should reach 100 million rubles.[5] The "Catalyst" MNTK is expected to produce 80 percent of the new catalysts scheduled for development in the 12th Five-Year Plan by the ministries of chemical, petrochemical, and fertillizer industries.[31]

The MNTKs weave a wide-ranging network of industrial linkages across industrial branches and diverse industrial ministries. Thus, the "Personal Computers" MNTK is expected to deal with four ministries in computer development, and 30 ministries in manufacturing parts and materials.[11] The "Rotor" MNTK includes 29 participating organizations belonging to 22 ministries.[28] The "Paton Institute of Electric Welding" MNTK operates enterprises of five all-union ministries.[15,26]

The size and structure of the MNTKs together with their new economic privileges provide a strong potential to resolve the perennial problems of Soviet advanced technology. These resources have been

described so far only in terms of plans, government decrees, and administrative actions. As is often the case in Soviet affairs, there is a wide gap between legislated intentions and actual practice. The next section deals with what some Soviet participants of the MNTK reform see as their early operational results.

V. EARLY SOVIET ASSESSMENTS OF THE MNTK SYSTEM

The basic purposes of the MNTK system have been repeatedly emphasized by Academy leadership: to integrate science and industry, to concentrate resources in priority areas of science and technology, to surmount bureaucratic obstacles in development and production, and to sweep away departmental barriers that have become the talk of the town. The MNTK principle will finally unite diverse collectives under "one roof" and the unified management plan will help speed up the entire cycle from the basic idea to production of new equipment.[25-28] There is a broad consensus among participants of the MNTK reform that these goals are important, urgent, and long overdue. However, there is also nearly as much agreement that the dynamism inherent in the concept of the MNTKs has been altogether absent in their practical implementation.

As Yu. A. Ovchinnikov, vice-president of the Academy of Sciences, put it: "There is the paradox: The top [leadership] designates the MNTK as an instrument of acceleration. But then their material resources, their base, are still being realized by traditional, unhurried methods."[36]

Early responses from the field dealing with the organization and operation of the new MNTKs paint an unsatisfactory and pessimistic picture of MNTK development.

Perhaps the most significant response comes from B. Ye. Paton, president of the Ukrainian Academy of Sciences, since he is the originator of the MNTK system. Although the new MNTKs are far from being fully operational, Paton sees them as incorrigibly fragmented and hard-to-manage conglomerates of enterprises and scientific research organizations. The right to independent contracting and to control the financing of R&D projects as the main lever to force innovation, granted to MNTKs, has not been realized. Neither have the many resolutions to improve the linkage between science and production because of incompetence and the frequent unwillingness to use the new laws and opportunities. As a result, Paton says, the MNTKs are already called paper tigers.

Paton attributes many of these problems to what he calls the unjustified and artificial rules, established by Gosstandart SSSR (State Committee for Standards), governing the procedures the MNTKs must follow in guiding their research projects to the production stage. The excessive volume of the required technical documentation and interagency agreements entails a time loss of up to 2-3 years. He concludes that the attainment of world level in a number of technologies will remain wishful thinking if the present situation is allowed to continue.[30,37,38]

The slow pace of the organization of MNTKs was also criticized by such Academy leaders as first vice-president V. A. Kotel'nikov, vice-president P. N. Fedoseyev, chairman of the Academy's Siberian Department V. A. Koptyug, and L. M. Brekhovskikh, secretary of the Academy's Department of Oceanology, Atmospheric Physics, and Geography.[5,23,31,39]

The main problem at this time appears to be the reluctance of the industrial ministries to cooperate with the Academy's component in the MNTKs and to adapt to more efficient ways of introducing the results of R&D into production within the MNTK system. There are no adequate moral and material incentives for the industry to change its old practices.[23,28,31,39]

In the individual MNTKs, the industrial enterprises are unwilling to discontinue a significant portion of their production lines in order to shift production to new MNTK-specified technologies.[33] The ministries fail to provide operational funding to the MNTKs to match the Academy's contributions.[32] The traditional forms of materials and equipment supply are being retained, requiring that resources be ordered years in advance.[25] Finally, the MNTKs must deal with too many ministries and agencies, causing excessive bureaucratic problems.[11]

A good analysis of MNTK problems has been provided by V. S. Golubev, deputy director for research of the Academy's Research Center of Industrial Lasers (NITsTLAN), the head organization of the "Industrial Lasers" MNTK. Golubev lists the following major causes of the poor performance of the network:[14]

1. The ambiguous legal status of the MNTKs that allows the organizational fragmentation of the R&D cycle to continue. The applied research institutes and production associations who are members of the MNTKs continue their administrative subordination to their respective ministries and identify their interests with the latter.
2. Lack of unified financial or material resources among the MNTK components, making it difficult to maintain unified wage and incentive standards.
3. The fact that the MNTKs are governed by goal-oriented (tselevyye) programs which are not included in mandatory state plans. Gosplan and the State Committee for Science and Technology have not yet confirmed plans that would force cooperation among MNTK components. Therefore, no official sanctions can be applied for violations of delivery dates or of contractual obligations by MNTK suppliers.

The immediate objective of the MNTKs at the present stage is procurement of basic facilities and personnel. Some of these facilities are obtained from capital investment. For example, the share of capital investment for the pilot plant and technological support base of the Academy of Sciences has almost quadrupled since the 10th Five-Year-Plan, reaching 15 percent in the 12th Five-Year-Plan. [5] Other facilities are to be realized from conversion of existing industrial assets. The conversion process has its own set of pitfalls.

The "Industrial Lasers" MNTK also provides a comprehensive example of the problems involved in the establishment and early operation of MNTKs and in the conversion process. A commentary on these problems comes from G. A. Abil'siitov, general director of the MNTK, and Golubev, both representing the R&D viewpoint, V. G. Zav'yalov, director of the Sibelektroterm Production Association, representing the production viewpoint, and an observer, N. T. Stavrukov of Chuvash State University.

The "Industrial Lasers" MNTK is under joint jurisdiction of the Academy of Sciences, USSR, and the Ministry of Electro-technical Industry (Minelektrotekhprom). It has been established to develop and

produce 1 to 10 kW laser systems to be used for welding pipes and driveshafts, cutting composites, superhard alloys, and ceramics, surface treatment of materials and machine parts, and plasma powder sputtering.

Beside NITsTLAN, whose first stage was put in operation in February 1986, the MNTK is to include a series of organizations designed to achieve a complete sequence of research-to-production stages.[14,15,35,40] Golubev notes that there is a hierarchy among these organizations in the degree of association with the MNTK: organizations belonging to the MNTK are members (vkhodyashchiye v MNTK), further away are participants (prinimayushchiye uchastiye), and furthest are collaborators (sotrudnichayushchiye).[14] It is not clear, however, what limitations, if any, are imposed on the rights and obligations of participants and collaborators, as distinct from members of the MNTK.

Basic research of the "Industrial Lasers" MNTK is to be performed by six member research institutes, five of the Academy of Sciences, USSR, and one (Institute of Atomic Energy) of the State Committee for Atomic Energy. Applied research is represented by the collaborator Institute of Theoretical and Applied Mechanics of the Siberian Department of the Academy of Sciences. Development is in the hands of two member institutes under the jurisdiction of Minelektrotekhprom: the All-Union Research Institute of Electro-thermal Equipment and the All-Union Research Institute of Electric Welding Equipment. The Moscow Electro-thermal Equipment Plant of Minelektrotekhprom, member, is the pilot plant, and the Sibelektroterm Production Association, participant, the Tbilisi Electric Welding Plant, member, and the Induktor Plant, participant, all of Minelektrotekhprom, will handle mass production.

The two industrial research institutes and the Moscow and Tbilisi production plants have all been working to meet their current operating plan quotas. According to Abil'siitov, they will have to be released from this committment, and converted, to meet the needs of the MNTK.[40] He gives no information as to what organization, if any, will take over their previous research and production responsibilities.

So far, the two industrial institutes of Minelektrotekhprom responsible for the design and prototype construction of the laser systems have failed to assign enough resources to the project. As a result, a large gap has opened between research and the later stages of

the R&D cycle, so that the chain from scientific idea to its realization has not closed. This, in turn, has led to a disproportion between the scientific and production components of the MNTK. The scientific component is the much stronger of the two and the scientist-leaders of the MNTK are largely ignorant about engineering design work and production.[14]

Minelektrotekhprom has also failed to implement mass production of industrial lasers within the MNTK. This task had been levied on the ministry in the framework of the 11th Five-Year Plan.[14] In discussing this failure, Zav'yalov identified the lack of proper specialization in the production of laser devices as the major bottleneck in the early stage of operation of the MNTK.[41]

The leading production plant of the Sibelektroterm Association has been manufacturing large-size electro-thermal equipment measured in tens of meters and weighing hundreds of tons. This is in sharp contrast with the realities of laser technology, which requires precise and delicate treatment based on a very different psychology and ideology of production. As a result, the main production shops have not been able to participate in the manufacture of laser systems. Laser development is being performed there on a small scale by the same specialists engaged in the main production operations of the Association.

A critical component of laser systems is precision optics. Stavrukov notes that optics represents the greatest stumbling block today in the development of laser technology and that it is impossible under current Soviet conditions to organize the supply of optical devices on a cooperative basis.[42] The optics problem shows clearly the fallacy of imposing the task of manufacturing highly sophisticated precision equipment on generalized production enterprises. Golubev says that optical devices and microprocessor-based controllers for industrial laser tools can only be obtained by the MNTK if it is allowed to build its own specialized production facilities endowed with proper equipment and expertise. Permission for such facilities has not been granted by Minelektrotekhprom.[14]

In addition to facility constraints, there are problems with qualified personnel. There is a shortage of engineers in Siberia, compounded by a rigid limit imposed by the Ministry on the wage fund and its refusal to allocate separate wage funds for the laser work.[41]

Zav'yalov concluded that the establishment of a specialized laser production base in the Sibelektroterm Association remains in doubt. Speaking in more general terms, Golubev voiced a similar doubt that the MNTK network will successfully cope with the problems of interagency cooperation and implement its program.[14,41] In the words of Abil'siitov, "MNTKs must be established in a revolutionary, dynamic way. Otherwise all will drown in bureaucratic phraseology, opportunistic adjustments, convenient agreements, etc. Many new endeavors were mired on that road."[40]

VI. CONCLUSIONS

The MNTK system is clearly intended by the highest levels of Soviet leadership to be the principal means of solving the problem of advanced technology development. This is evident from the simultaneous application of three key measures, unprecedented in Soviet industrial policy: first, the massive engagement of the research institutes of the Academy of Sciences, the primary developer of advanced technologies, in joint association with industrial organizations; second, the size and scope of the individual MNTKs, exceeding those of the industrial NPOs; and third, the extensive management and fiscal policy powers granted to the MNTKs, going far beyond those granted in the past to the NPOs.

The MNTK system addresses the institutional barrier problem in two dimensions at once: by integrating under one organizational roof both the entire research-to-production cycle and the different subject areas of research and branches of industry that are needed to develop a given technology. This double integration effort also provides the opportunity to redress the imbalance between science and industry: the scarcity of technological support in the Academy, and scarcity of scientific expertise in the industrial ministries.

Perhaps the most significant of the new fiscal privileges of the MNTKs is the power to change the approved resource allocations plan in midcourse. The right to demand, and obtain, additional resources above planned levels can go a long way toward making the system more responsive to changing circumstances, typical of the development of advanced technologies.

The MNTK structure armed with its economic rights and privileges is expected to overcome the entire complex of Soviet problems with industrial innovation: economic disincentives, jurisdictional barriers, and operational misallocation of resources. This task is much more difficult for the MNTKs than for the industrial NPOs, if only because the bureaucratic barrier between the Academy of Sciences and industry is more formidable than any such barriers that may exist within the industrial system.

Many NPOs have failed to reach their objectives because of the lack of economic incentives, insufficient legal powers, and failure to enforce the powers they have. Although the basic NPO principle was integration of their component institutions, NPOs achieved only administrative, not operational, integration. Thus, the imposition of an NPO structure on a group of diverse organizations often became more a matter of form than of substance.

The charter of the MNTKs appears to reflect greater scope and more extensive rights than those granted the NPOs. But the question remains whether the MNTKs will fare any better. At this time, one-and-a-half years after the empowering resolution of the Council of Ministers, the returns from the field suggest that the answer is largely negative. The complaints from MNTK directors, managers of their industrial components, and participating scientists strongly echo former responses to the NPOs: the MNTK rights are not being enforced and they do not go far enough. Key problems are the still ambiguous legal status of the MNTKs, continuing organizational fragmentation of the R&D cycle, lack of unified wage and incentive standards, and the reluctance of Gosplan and the State Committee for Science and Technology to reflect the MNTK objectives in state plans. The last point nullifies many of the economic rights of the MNTKs since, according to Golubev, contractual obligations can be enforced only in connection with activities approved in the state plans.

The MNTKs also appear to suffer in the area central to their basic concept--the interface between advanced scientific research and the existing industrial capability. Rather than build new specialized plants for the MNTKs, industrial facilities engaged in the manufacture of traditional products have been diverted to serve the Academy's institutes. The traditional methods of these facilities and the skills of their personnel are not ready to meet the standards of quality and precision required by the new technology.

This problem reveals a fundamental weakness of Soviet leadership--failure to understand the revolutionary nature of advanced technology. The latter is incompatible with the conservatism, parochialism, and incremental advance characteristic of traditional Soviet industrial

practices, and calls for much greater emphasis on R&D, higher tolerance of risk, uninhibited flow of information, and, in the words of one Soviet critic of the reform, "an entirely different psychology and ideology of production."

The conservative bias of Soviet leadership is also apparent in the spectrum of scientific and technological profiles assigned to the new MNTKs. The tendency to upgrade traditional technologies, rather than develop and produce new ones, can be deduced from the facts that over one-third of all MNTKs are not led by the Academy of Sciences; the heavy concentration of MNTKs in metallurgy, machine-building, and petroleum industries; and the poor coverage or absence of MNTKs in areas where the Soviet Union is particularly weak--computer technology, electronics, plastics, and composite materials.

It can be argued that the topical conservatism of the MNTK system reflects the economic disparity between the East and the West. The sustained demand of Western societies for ever more advanced information, communications, transport, entertainment, and other services and goods has no comparable equivalent in the Soviet Union. As a result, the MNTKs represent what Soviet leadership considers as technologies appropriate to the present level of development of Soviet society.

This argument would assume that the MNTK network has been intended mainly to serve the needs of the civilian sector of the Soviet economy. But an equally important purpose is the establishment of a strong advanced-technology base to drive further developments of value to both the civilian and the military sectors. Although the Soviet military procurement system has been quite effective in traditional technologies, the advanced technology problem is nationwide, as has been amply demonstrated by the situation prevailing in the computer field. Progress in advanced technology for the military also depends on a well integrated science and industry system. Since the MNTKs represent the currently favored means of such integration, it is possible to conjecture that some MNTKs are dedicated to the military. Their lower visibility in the Soviet press could then account for the lack of data on the "Mikrofotoelektronika" (Miniaturized Electron-optics Sensors), "Svetovod" (Light Conduit), and "Radiatsiya" (Radiation) MNTKs.

In their present, early period, the MNTKs seem to be failing in all three main categories of innovation problems--economic, organizational, and operational. Of the three, the most damaging is the economic factor because it means that industry has no real incentives to introduce new technologies, the mainspring of innovation. However, the establishment of such incentives probably involves a deeper restructuring of the Soviet economy than what Soviet leadership is prepared to attempt.

The disappointing record of Soviet struggle with innovation has had some exceptions. In the case of NPOs, such an exception is the Kriogenmash NPO. But its success can be attributed to the efforts of Belyakov, its organizer, and Kapitsa, the founder of cryogenic technology, rather than to the merits of the NPO system. In a similar way, Paton's MNTK will probably live up to its promise thanks to Paton's experience, understanding of the problems, and ability to manipulate the levers of power. It is a big question if the effectiveness of talented individuals can be transposed from a local to a national level, involving the entire MNTK network.

The concept of MNTK also has its detractors and competitors within the Soviet R&D establishment. In the Academy of Sciences, Velikhov is advocating and expanding the network of interagency centers with similar objectives to the MNTKs, but to be controlled exclusively by the Academy. Although some of these centers are actually participating in the MNTKs, Velikhov studiously avoids any reference to the latter. In industry, Belyakov has been successfully promoting the VNPOs, which he regards as a favorable alternative to the MNTKs. The establishment of the Academy's interagency centers and the industrial VNPOs appears to be totally uncoordinated with the MNTK drive, giving the impression of chaotic planning and management at the top.

At this time, the Central Committee regards MNTK as the preferred system. Its expansion demonstrates an earnest effort of the Soviet leadership to solve the problem of introducing the results of scientific research into industrial production. But the urgency of this effort is reflected only in the speed with which the MNTKs were set up, amounting to better than one MNTK per month, and in the insistence of the Central Committee to shorten the organizational period. Once the MNTKs have

been established, the further steps necessary to ensure their viability, such as procurement of facilities, resources, and the all-important economic powers, appear to have been mired in the usual bureaucratic process.

In the judgment of Soviet observers, the outlook for the MNTK network as the principal instrument for redressing Soviet imbalance in advanced technologies is not encouraging. Bureaucratic resistance coupled with the unprecedented complexity of the new organizations may doom them to share the fate of the NPOs. The difference is that now the future of advanced technologies is in question, affecting Soviet capability for technological and military competition with the West.

It is possible to conclude that specialized organizational structures that the Soviets have been devising in ever increasing complexity to solve their industrial technology problems are not likely to do their job within the present economic system. The current restructuring drive offers the promise to change at least the worst aspects of that system. Along with other components of Soviet science and industry, the MNTKs have much to gain, particularly from the new openness (glasnost'), since the free flow of information is a critical prerequisite to the development of advanced technology. But the possible success of the MNTKs on the heels of a successful restructuring drive, if it materializes at all, would flow from the generic improvement of Soviet industrial relations rather than from the particular organizational features and privileges of the MNTK network.

Appendix
REPORTED MNTKS

COMPUTERS AND AUTOMATION

MNTK: Personal'nyye EVM (Personal Computers)

Head organization: Institute of Informatics Problems

Jurisdiction: Academy of Sciences, USSR

General director: B. N. Naumov

Makeup: Includes scientific research institutions, design and engineering organizations, and testing enterprises.[23]

Mission: Develop and produce personal computers.

Serious problems: No R&D and experimental production facilities; funding provided only by the Academy, none by industrial ministries; excessive bureaucracy because of dealing with 34 ministries in pursuit of its mission--four ministries in computer development, and 30 ministries in manufacturing parts and materials; confusion of brands and software.[11]

MNTK: Robot (Automated Control Systems)[11]

Head organization: Experimental Research Institute for Metal-cutting Machine Tools[24]

Jurisdiction: Ministry of Machine-tool Industry (Minstankoprom)

Mission: Head all nationwide activities for the development of robotic complexes and flexible automated systems to modernize

mechanical materials treatment and assembly processes.[24]

MNTK: Avtomatika (Computer-aided Automation)[11]

No data.

ELECTRON-OPTICS AND SCIENTIFIC INSTRUMENTS

MNTK: Tekhnologicheskiye lazery (Industrial Lasers)

Head organization: Scientific Research Center for Industrial Lasers, (NITsTLAN), Academy of Sciences, USSR

Jurisdiction: Academy of Sciences, USSR, and USSR Ministry of Electro-technical Industry

General director: G. A. Abil'siitov[11]

ORGANIZATION OF THE "INDUSTRIAL LASERS" MNTK[a][14,15,35,40]

Institution	Affiliation	Status[a]
	Head Institution	
Scientific Research Center for Industrial Lasers (NITsTLAN)	Academy of Sciences	member
	Basic Research	
Institute of General Physics	Academy of Sciences	member
Lebedev Physics Institute	Academy of Sciences	member
Institute of Mechanics Problems	Academy of Sciences	member
Institute of Crystallography	Academy of Sciences	member
Institute of High Temperatures	Academy of Sciences	member
Institute of Atomic Energy	State Committee for Atomic Energy	member

	Applied Research	
Institute of Theoretical and Applied Mechanics	Academy of Sciences, Siberian Department	collaborator
	Development	
All-Union Research Institute of Electro-thermal Equipment	Minelektrotekhprom	member
All-Union Research Institute of Electric Welding Equipment	Minelektrotekhprom	member
	Pilot Plant	
Moscow Electro-thermal Equipment Plant	Minelektrotekhprom	member
	Mass Production	
Sibelektroterm Association	Minelektrotekhprom	participant
Tbilisi Electric Welding Plant	Minelektrotekhprom	member
Induktor Plant	Minelektrotekhprom	participant

[a]Organizations belonging to the MNTK are members (vkhodyashchiye v MNTK), further away are participants (prinimayushchiye uchastiye), and furthest are collaborators (sotrudnichayushchiye).[14]

Serious problems: Lack of specialization in the production of laser devices, delays in key components of the R&D cycle, lack of a projected industrial research institute to develop technological support, and lack of a design bureau.[40] There is inadequate linkage between the Academy of Sciences and the Minelektrotekhprom with which the Academy shares jurisdiction over the MNTK.[35]

MNTK: Svetovod (Light Conduit)

Head organization: Institute of Radio-engineering and Electronics

Jurisdiction: Academy of Sciences, USSR

Makeup: Includes scientific research institutions, design and engineering organizations, and testing enterprises.[23]

MNTK: Mikrofotoelektronika (Miniaturized Electron-optics Sensors)[11]

No data.

MNTK: Nauchnyye Pribory (Scientific Instruments)

Head organization: Leningrad Scientific-technical Association

Jurisdiction: Academy of Sciences, USSR

General director: M. L. Aleksandrov

Makeup: Includes a number of plants (Orel plant of Minpribor), design bureaus, and research institutes.

Mission: Produce one-third of all scientific precision instruments required by the USSR by 1990.

Serious problems: Reluctance of Minpribor to stop mass producing items in its MNTK plants that are not in keeping with MNTK specialization; retention of the traditional forms of materials and equipment supply which require ordering resources two years in advance.[25]

MNTK: Radiatsiya (Radiation)[11]

No data.

METALLURGY

MNTK: Institut Elektrosvarki im. Ye. O. Paton (Paton Institute of Electric Welding)

Head organization: Paton Institute of Electric Welding

Jurisdiction: Academy of Sciences, UkrSSR

General director: B. Ye. Paton

Makeup: Includes design bureaus, experimental plant, pilot plants for welding equipment and electrical metallurgy, and enterprises of five all-union ministries.[15,26]

MNTK: Metallurgmash (Metallurgy Machinery)

Head organization: All-Union Scientific Research, Planning, and Design Institute of Metallurgical Machines

Jurisdiction: Ministry of Heavy and Transport Machine Building

Mission: Solve scientific and technical problems in the development, manufacture, and industrial introduction of new machines and devices for steel making, pipe rolling, and stamping, based on new advanced technological processes.[15]

MNTK: Poroshkovaya metallurgiya (Powder Metallurgy)

Head organization: Institute of Problems of Materials Science

Jurisdiction: Academy of Sciences, UkrSSR

General director: V. I. Trefilov.[27]

MACHINE-BUILDING

MNTK: Rotor (Automated Conveyor Lines)

Head organization: Design Bureau for Automated Lines (KBAL)

Jurisdiction: Probably industry

General director: L. N. Koshkin

Makeup: Includes 29 participating organizations belonging to 22 ministries.[28]

Mission: Develop and introduce rotor conveyor lines in industry. Rotor conveyor lines, a new class of machinery, convey together the machined objects and machining tools. They are being introduced at plants of the chemical, electrical equipment, automotive, radio, and other industries.[29]

Serious problems: Failure to create a system of moral and material incentives for the workers, inadequate scope of operations, unduly long organizational period, mediocre quality.[28]

MNTK: Mekhanbor (Advanced Crushing and Pulverizing)

Head organization: All-Union Scientific Research and Design Institute for Mechanical Processing of Minerals

Jurisdiction: Ministry of Nonferrous Metallurgy

General director: V. I. Revnivtsev

Makeup: To include 10 industrial branch scientific research institutes, 10 Academy and VUZ institutes, and industrial combines Uralmash, Novokramatorskiy Mashinostroitel'nyy Zavod, and production associations.[11]

Mission: Coordinate nationwide processing of raw materials, establish regional scientific and technical equipment and training centers, develop a new generation of crushing and pulverizing equipment to ensure more selective breaking of ores and materials, reduce metal and electric power consumption, and reduce capital expenditures on ore preparation.[11,15]

MNTK: Impul'snyye Mashiny (Pulsed Machines)[11]

No data.

MNTK: Nadezhnost' mashin (Machine Reliability)

Head organization: Blagonravov Institute of Machine Science

Jurisdiction: Academy of Sciences, USSR

General director: K. V. Frolov

Makeup: To include the Institute of Superplasticity of Metals and the Control Design Bureau of Unique Instrument Building, the Spektr, Burevestnik, and Tochmashpribor NPOs, the Central Steam Boiler and Turbine Institute, and the Vibropribor and Tenzopribor plants.[30] The Blagonravov Institute, the head organization of MNTK, was once transferred from the Academy to industry, and has now been brought back to Academy jurisdiction.[43]

Mission: Develop diagnostic systems, test stands, equipment, and sensors to increase the reliability and service life of machines and components, as well as to reduce substantially machine metal content.[15]

Serious problems: The plants are unable to implement production plans until Gosplan frees them from previous tasks and provides them with production facilities. Developed by the Academy of Sciences and GKNT, the charter of the MNTK has not yet been approved.[30]

CHEMICAL INDUSTRY

MNTK: Katalizator (Catalyst)

Head organization: Institute of Catalysis, Siberian Department

Jurisdiction: Academy of Sciences, USSR

General director: K. I. Khamareyev

Makeup: Includes 14 research institutes and enterprises of six ministries and agencies. Its national importance is indicated by the fact that 80 percent of new catalysts scheduled for development in the 12th FYP by the ministries of chemical, petrochemical, and fertillizer industries will be produced by the MNTK.[31]

Mission: Develop effective catalysts and fundamentally new catalytic processes to increase the economic effectiveness of energy resources and to reduce production cost of chemical products.[15]

Serious problems: The organization of this MNTK is far from completed. After completion, it should be allowed to work for two to three years before its usefulness can be evaluated and measures for further improvement can be formulated.[31]

MNTK: Antikor (Anticorrosion)

Head organization: All-Union Interbranch Scientific Research Institute for Protection of Metals Against Corrosion

Jurisdiction: State Committee of Science and Technology

Mission: Develop fundamentally new types of equipment and technologies that ensure high corrosion resistance, wear resistance, strength of materials and parts, and reliability and durability of machines and structures.[15]

Serious problems: Failure to include such prominent corrosion research organizations as the Institute of Physical Chemistry of the Academy of Sciences, USSR, and the Karpov Physico-chemical Institute of the Ministry of the Chemical Industry.[32]

MNTK: Termosintez (Thermosynthesis)

Head organization: Institute of Chemical Physics

Jurisdiction: Academy of Sciences, USSR

Makeup: Includes scientific research institutions, design and engineering organizations, and testing enterprises.[23]

MNTK: Membrany (Membrane Technology)

Head organization: Polimersintez NPO and All-Union Scientific Research Institute of Synthetic Resins[15]

Jurisdiction: Ministry of Chemical Industry[15]

General director: L. Pokrovskiy

Makeup: Includes seven NPOs and production associations.[44] Will include scientific institutes, a design bureau, experimental bases, and problem-solving laboratories of Minkhimmash, Minlegprom, and Minvuz.[15]

Mission: Develop highly selective membranes for separating gaseous and liquid media, high-performance reverse osmotic, ultrafiltration, and electrodialysis automated separators for

extensive use in the national economy. Intended for mass production.[15]

Serious problems: Unified research plan established late; production facilities and scientific training center not yet installed.[11]

PETROLEUM INDUSTRY

MNTK: Nefteotdacha (Oil Extraction)

Head organization: All-Union Scientific Research Institute of Petroleum and Gas

Jurisdiction: Ministry of Petroleum Industry

Mission: Develop advanced systems for the extraction of petroleum deposits, and effective technologies and equipment to stimulate productive beds aimed at complete recovery of oil and gas from deep wells.[15]

Serious problems: The Institute of Physical Chemistry has been included in the plans for the complex. It has, however, refused to participate in this MNTK because it has no specialists in oil prospecting or petroleum chemistry.[32]

BIOTECHNOLOGY AND MEDICINE

MNTK: Biogen

Head organization: Shemyakin Institute of Bio-organic Chemistry

Jurisdiction: Academy of Sciences, USSR

Makeup:
Special Design Bureau of Biological Instrument Making, Pushchino,

Biolar NPO, Olayne, Latvian SSR,
Institute of Molecular Biology, Moscow,
Institute of Bio-organic Chemistry,
Institute of Biochemistry and Physiology of Microorganisms, Pushchino,
Institute of Plant Physiology, Moscow,
Institute of General Genetics, Moscow,
Main Botanical Garden, Moscow,
Institute of Chemistry of Bashkir Affiliate with Experimental Base, Ufa,
Institute of Biology of Bashkir Affiliate, Ufa

Mission: Use genetic and cellular engineering techniques, develop new types of biologically active substances and compounds for early diagnosis and treatment of diseases in medicine, veterinary medicine, and horticulture.[15,36]

MNTK: Latbiotekh (Latvian Biotechnology)

Head organization: Kirkhenshteyn Institute of Microbiology

Jurisdiction: Academy of Sciences, Latvian SSR

Makeup: Includes 22 organizations

Mission: Coordinate implementation of the "Biotekhnologiya" republican scientific and technical program which is aimed at developing new biotechnology processes and equipment, various medicinal preparations, genetic engineering, environmental protection methods, and biological sources of energy.

Serious problems: Delayed charter ratification, lack of own wage fund, lack of money and materials for the construction of experimental and engineering facilities.[33]

MNTK: Mikrokhirurgiya glaza (Eye Microsurgery)

Head organization: Moscow Scientific Research Institute of Eye Microsurgery

Jurisdiction: RSFSR Ministry of Health

General director: S. N. Fedorov

Makeup: Will include experimental plants and 12 branches throughout USSR.

Mission: Computer-controlled assembly-line surgery with each phase monitored with color videocamera attached to a voice-controlled microscope. Expected to perform 1000 operations per day, 200,000 per year. To be operational in three years. Will be given authority to solve any problem in any ministry or institution under its supervision, and to place orders abroad for instruments, lenses, and equipment without a middleman. A new system of financing permits it to cover expenses in research and medical treatment as it sees fit.[16]

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